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Case Report

Radiopaque stomach contents in postmortem CT in suicidal oral medication intoxication: Report of three cases

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ABSTRACT

In clinical medicine, plane radiography is used for detecting the remains of medications in the stomach in oral medication intoxication cases. Since postmortem computed tomography (CT), performed prior to autopsy, is currently intensively entering the forensic routine, the technique was applied to three fatal cases of oral medication intoxication. Here we report CT and autopsy findings for these cases.

In all three cases, hyperdense areas within the stomach content were documented. The measurement of Hounsfield Units (HU) beyond 74 HU showed mean values of 338, 88 and 98 HU. Postmortem CT also showed brain edema and pulmonary aspiration in one case. At autopsy, tablet remains in the stomach were detected microscopically in all three cases. The ex vivo CT scans of the ingested medicaments showed similar HU values.

Despite the fact that further case studies are necessary beyond this one, and in spite of its limitations, postmortem CT was found to be a useful screening and documentation method for stomach contents in oral medication intoxication.

1. Introduction

In forensic medicine, postmortem radiological examination of the stomach in medication intoxication cases is unusual since clues for tablet remains in the stomach contents can be macroscopically seen at autopsy or in microscopic examination of stomach contents[1], and because chemical–toxicological analysis of stomach contents and blood allow for qualitative and quantitative analysis of the intoxication substance. In clinical medicine, plane radiography is applied for detection of the remains of medications in the stomach in oral medication intoxication cases.[2–6]

One of the new forensic examination methods, currently intensively entering the forensic routine, is computed tomography (CT) that allows for rapid documentation, visualization, and diagnostics of whole bodies in a non-invasive manner.[7,8]

Recently, CT applied postmortem allowed the detection of radiopaque stomach contents in the first three cases of oral medication intoxication examined within the Virtopsy Project at the University of Bern. Postmortem CT and autopsy findings in these cases are reported here.

2. Material and methods

Between July 2000 and 2006, 140 selected autopsy cases with different causes of death underwent postmortem CT examination prior to autopsy. Three of these were suicide cases of ingestion of medications, which we report on here.

This study was approved by the ethics committee of the University of Bern.

2.1. Case 1

A 50-year-old man was found dead in his apartment. Advanced putrefaction of the body was seen. Several empty tablet packages of Nardyl® (sedative; active ingredients: promethazine HCl, hyoscyamine sulfate, atropine sulfate and scopolamine) and Detensor® (hypnotic; active ingredient: diphenhydramine) as well as empty vodka bottles were found close to the body.

2.2. Case 2

A 36-year-old man was found dead in his apartment. The inspection of the apartment showed a number of empty tablet packages of Entumin® (neuroleptic; active ingredient: clotiapine) as well as an empty vodka bottle and further alcohol.

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2.3. Case 3

A 43-year-old man, in custody, was found dead in his prison cell. A number of tablets of Surmontil® (antidepressive; active ingredient: trimipramine) and Depakine® (antiepileptic; active ingredients: valproic acid, sodium valproate), both of which had been prescribed for him, as well as a suicide note, were found close to the body on a table.

2.4. Imaging

Postmortem CT of these three cases was performed using a six-row scanner (Emotion 6, Siemens, Germany). Scanning parameters were as follows: raw data acquisition at 130 kV, 90 mAs, 1.25 mm collimation, rotation time 1.5 s, pitch 1.6 and image reconstruction by 1.25 mm thickness, 0.7 mm increment, B30 reconstruction kernel and matrix 512.

The volume of the stomach as well as the distribution of Hounsfield Units (HU) was assessed. For the measurements of mean HU values, a lower threshold value of 74 HU was applied and HU values higher than this were analyzed.

2.5. Ex vivo scans

All five medicaments were scanned in CT in an ex vivo study (Nardyl 50®-10 tablets; Detensor®-20 tablets; Entumin 40®-30 tablets, Surmontil 25®-50 tablets, Depakine 300®-100 tablets). One single tablet of each medicament was solved in some water in a plastic cup. Furthermore, all remaining tablets from the package of each medicament were solved in water in an additional plastic cup per medicament. The 10 cups with medicaments were stored for 24 h at room temperature and subsequently scanned in CT with the same scanning parameters as for cases, except the field of view, which was reduced to a cup size (12 × 12 cm). Additionally, one cup with pure water as a control was also scanned. The mean HU value of 10 measurements in different parts of each cup was calculated.

3. Results

3.1. Case 1

In postmortem CT, in addition to the advanced putrefaction hyperdense stomach contents were documented (Fig. 1). Radiologically, the whole volume of the stomach was measured to be approximately 150 cc. An exact measurement was impossible due to the putrefaction.

The range of HU values lay between 74 and 1118 HU, with a mean value of 338 HU and standard deviation (SD) of 160 HU.

At autopsy, tablet remains in the stomach were microscopically confirmed. Chemical–toxicological analysis detected diphenhydramine, active ingredient of Detensor® (sleeping pills) in blood at a concentration lower than the therapeutic one.

3.2. Case 2

In postmortem CT, in addition to pulmonary aspirations in both lungs and moderate brain edema, hyperdense areas in the stomach contents were documented (Fig. 2).

The whole stomach contents measured 395 cc. The documented HU range was 74–201 HU, with a mean value of 88 HU and SD of 14 HU.

At autopsy tablet remains were microscopically seen in the stomach. Quantitative and qualitative toxicological examinations were not performed.

3.3. Case 3

In postmortem CT, after partial stomach resection hyperdense stomach contents with some round contours were seen (Fig. 3).

The volume of the whole stomach contents was 210 cc. Analyzing its radiopacity, the HU range was found to be 74–226 HU. The mean value in this case was 98 HU with a SD of 22 HU. Two metallic clips in the wall of the stomach, as operative fixation residues, were also documented.

At autopsy, tablet remains in the stomach were microscopically seen and a tri-cyclic antidepressant was confirmed in urine. Quantitative toxicological examinations were not performed.

3.4. Ex vivo scans

The results of the ex vivo scan were in accordance with the postmortem scans (Fig. 4, Table 1). The highest HU values were measured by Nardyl 10® followed by Detensor®, Entumin 40®, Depakine 300® and Surmontil 25®. The single solved tablet was well visible only by Nardyl 10® and only partially recognizable by Surmontil® and Depakine® (Fig. 4). The multiple solved tablets were radiopaque in CT (Fig. 4).

4. Discussion

In clinical medicine, a plane X-ray of the stomach is recommended in cases with a suspicion of intoxication by medications.[3,5,6] O'Brien et al. examined 459 drugs in tablets and capsules in water using conventional X-ray radiographs.[4] According to their results, about 36% of the drugs were at least moderately radiopaque in radiographs.[4] A number of authors also reported good radiological detectability of bromine-containing medications,

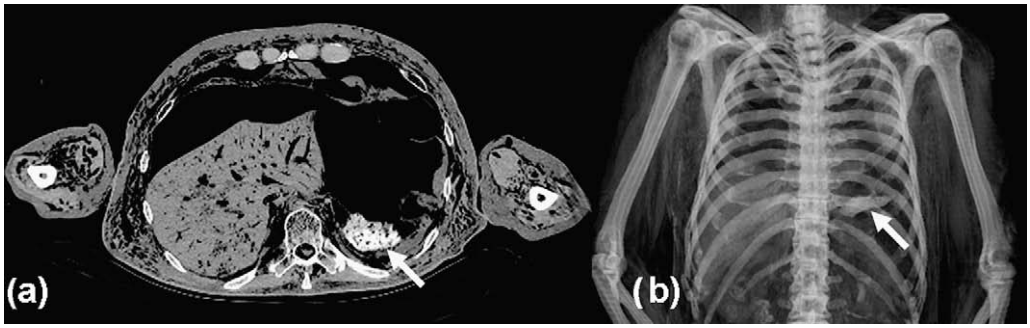

Fig. 1. (a) Axial CT image (FoV 70 cm) shows advanced putrefaction of the body as well as a clearly hyperdense stomach content (arrow). (b) In 3D reconstruction of the chest the stomach contents appears to resemble bone in its density.

Fig. 2. Axial CT image (FoV 19 cm) demonstrates the hyperdense parts of the stomach contents (arrow).

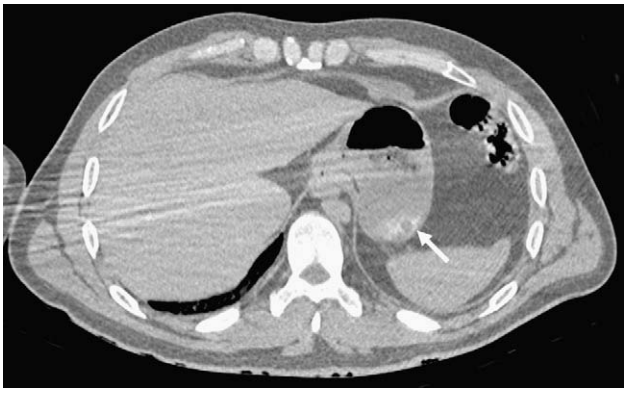

Fig. 3. Axial CT image (FoV 50 cm). Note the stomach contents that appear to be partly hyperdense with some round contours (arrow).

which frequently include hypnotics.[2,3,6] Negative findings are possible, resulting from a low amount of ingested medication (which can lead, however, to a good prognosis).[9,10] The detectability of such hypnotics derives from the relatively higher atomic number of bromine – compared to carbon and hydrogen – which is 35.[6] Recently Leth and Worm-Leonhard have observed tablet residues in stomach content found by routine postmortem CT.[11] The authors stated that the radiopacity in their case was probably caused by the ingested magnesium hydroxide.[11]

Within the Virtopsy project in Bern, three cases with suicidal ingestion of medications were documented. In all cases the stomach contents attracted attention due to increased radiological density, and tablet remains were diagnosed at autopsy. Interestingly, in the list of 459 medications, the radiographic detectability of which was examined by O'Brien et al., atropine sulfate (Nardyl® – case 1) and diphenhydramine (Detensor® – case 1), as well as trimipramine (Surmontil® – case 3) and valproic acid (Depakine® – case 3) were characterized as "drugs found to be not or minimally radiopaque".[4] Clotiapine (Entumin® – case 2), promethazine HCl, hyoscyamine sulfate, scopolamine (Nardyl® – case 1) and sodium valproate (Depakine® – case 3) were not investigated by O'Brien et al., but they also assigned promethazine and hyoscyamine to this group. This leads to the supposition that drugs classed by O'Brien et al. as "moderately radiopaque" and "drugs with a radiopacity approximately comparable with or greater than ferrous sulphate" should be even more easily detectable in postmortem CT.[4] This is also supported by the fact that in comparison to conventional X-ray radiographs used by O'Brien et al., CT provides multiple cross-sectional images, and better tissue resolution and volume information.[4]

In our three cases, knowing from medical literature and our own experience in postmortem cross-sectional radiology that protein and blood may show HU values up to 60–70 HU, in the measurement of the distribution of HU we took 74 HU as the threshold value, which was the next settable value on the workstation. Such a threshold was necessary since the distribution of HU of postmortem stomach contents varies between positive values and −1000, which is the HU value of gas in a postmortem stomach. Using this lower threshold value we aimed to exclude the gas and common stomach contents from the assessment.

The radiopacity of the stomach contents of the three cases showed values of 338, 88 and 98 HU, which were then confirmed in the ex vivo study. The radiological density of stomach contents in medication intoxication should depend on the medication itself, its amount, the amount of the leftover of food, as well as on the post-ingestion and postmortem intervals. The high HU value in case 1 can be explained by the fact that the ingested medicaments in this case showed also the highest HU values in ex vivo. Probably the seepage of water from the stomach contents through the advanced putrefaction of the stomach wall and consequent compaction of medication residues played also a role.

Importantly, a radiological examination of stomach contents in a suspicious intoxication is only a detection of radiopaque tablet remains. A positive finding can support the suspicion and make subsequent chemical–toxicological analyses necessary. A negative finding, however, has no evidential value. Radiological screening for medications in the stomach by full body postmortem CT can

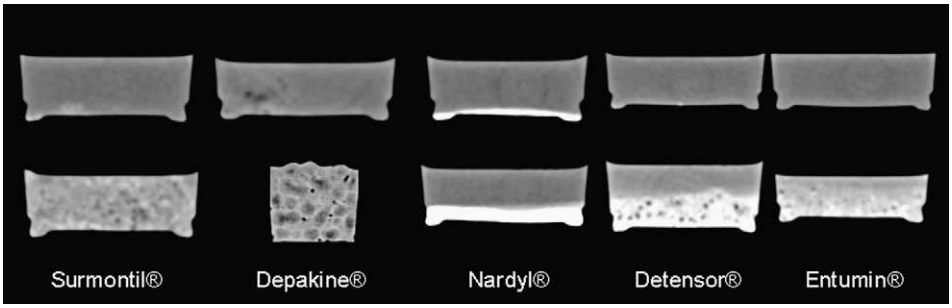

Fig. 4. The figure presents images the five medicaments scanned in ex vivo. On the top are images of one single tablet solved in water and below are images of the multiple solved tablets.

Table 1
The table demonstrates the measured HU values postmortem and in ex vivo.

		Postmortem		Ex vivo, many tablets		Ex vivo, 1 tablet	
		Mean HU	Max HU	Mean HU	Max HU	Mean HU	Max HU
Case 1	Detensor®	338*	1118*	144	251	77	82
	Nardyl®			308	782	186	295
Case 2	Entumin®	88	201	120	209	77	86
Case 3	Surmontil®	98	226	83	229	77	85
	Depakine®			97	151	84	140

Note that the case 1 had an advanced putrefaction (*). The mean HU value of the control cup with pure water was 0.

only detect material possessing increased X-ray opacity, it cannot yield the evidence of medication intoxication that chemical–toxicological analysis can. Many medications lack sufficient X-ray attenuation, and false negative results should be considered. Though, the medicaments studied in our ex vivo study all showed high HU values when multiple tablets were solved.

Examination of intoxication cases using postmortem CT allows, first of all, for digital, objective, and non-invasive documentation and visualization of stomach contents (Fig. 1), independent of whether the case is going to be autopsied or only externally inspected. Radiological examination might indicate a longer survival time after medication ingestion by demonstrating passage of radiopaque stomach contents into the duodenum.[2]

In cases that have to undergo both postmortem CT and chemical–toxicological analysis, the recently introduced postmortem CT-guided biopsy can further extend the concept of minimally invasive autopsy.[11,12] We suppose that percutaneous, minimally invasive sampling of probes of stomach contents for microscopic and chemical–toxicological examination using CT-guided biopsy with aspiration needles might contribute to the qualitative and quantitative evidence of the intoxication substance.[12,13] Such combination of the methods may play an important role in cases in which consent for a full autopsy is not forthcoming due to relatives, religious tradition, or other factors, singly or in combination.

Presently, CT alone as a non-invasive imaging method cannot be imagined as a routine test for presence of medication in the stomach. Here, we report on the CT detection of medications in the stomach, which increases the diagnostic possibilities of postmortem imaging. The only way to CT for testing the ingestion of medication as an alternative to autopsy might be in combination with minimally invasive biopsies of stomach contents, the toxicological examination of which should then be performed. As a matter of course, further serious studies on this issue are necessary. Differential diagnosis of different radiopaque gastric contents is one topic that ought to be addressed in future studies. According to our own experience with 140 postmortem CT scanned cases, no further visually detectable radiopaque stomach contents were observed, except in one case with a milk tooth in the stomach.

In addition to stomach findings, postmortem CT is useful in the diagnostics of concomitant findings in medication intoxication such as brain or lung edema, or pulmonary aspirations.[7,14] In our cases, postmortem CT correctly showed pulmonary aspirations in both lungs and a moderate brain edema in case 2.

In case 3, two metallic clips in the wall of the stomach as operative fixation residues after partial Bilroth II stomach resection were detected radiologically. Postmortem CT was already reported as a reliable method in non-invasive detection of foreign bodies, which may play a role in identification of such bodies.[15] Finally, according to recent literature postmortem CT is reported to be an accurate method for postmortem, non-invasive demonstration of bony and soft tissue trauma.[7,16] The question of costs for postmortem CT examination was also already addressed.[16]

The major limitations of our study include the following: (1) we have only three cases; and (2) quantitative chemical–toxicological analysis was performed only in case 1. Systematic and controlled studies including postmortem CT of the stomach contents and qualitative and quantitative chemical–toxicological analysis of the intoxication substance are necessary to evaluate the utility of postmortem CT in detecting oral medication intoxications.

A limitation of the approach, which we believe is only of temporary character, is the fact that postmortem CT is a new examination method and, currently, only a limited number of forensic institutions work with their own CT scanner.

Our results show that non-invasive cross-sectional radiological examination can provide a suspicion of oral medication intoxication, which can then be proved or disproved by chemical–toxicological examination. For this reason as well as the advantages mentioned above, postmortem CT examination of fatal cases of oral medication intoxication can be recommended. This is also due to the utility of obtaining further experience in this forensic radiological domain.

As an outlook for the future, we believe that with further development of minimally invasive autopsy a combination of postmortem radiology with chemical–toxicological analyses might optionally replace conventional autopsy, providing that other forensically relevant findings are either excluded or detectable using radiology and toxicology.

Despite the fact that further case studies are necessary, and regardless of current limitations, postmortem CT is a useful screening and documentation method for stomach contents in oral medication intoxication.

Conflict of Interest

We are confirming that the authors did not receive grants or outside funding in support of their research for or preparation of this manuscript. They did not receive payment or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

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Ethical Approval

None declared.

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